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Approximating the Operator of the Wave Equation using Deep Learning

The solution of the wave equation is required in a wide variety of fields, such as seismology, electromagnetism, and acoustics. In the last few years, a number of deep learning methods have been developed for the solution of PDE-based problems, with the objective of producing techniques that are more flexible and faster than the traditional FEM, FD, FV approaches. Deep operator networks (DeepONet) attempt to solve PDEs by learning the inverse of the differential operator for a wide class of initial data, rather than learn a single solution. However, this approach is especially expensive for problems containing high frequencies, such as those with the linear wave equation.

For the approximation of the homogeneous wave equation, we present a neural network architecture that is based on the integral representation formula of the wave equation. This architecture yields a faster learning and a better generalization error when compared to the classical DeepONet architecture. Moreover, with the proposed architecture, a trained network can be retrained for solutions with higher frequencies which results in an efficient learning strategy for high frequency functions. Numerical results in 1D and 2D will be presented to analyze frequency dependent convergence of the proposed approach.